A portion of Page 207 has been claimed confidential. This portion is releasable to persons who who submit a FOIA request.

(vii) Cattle Ear Tags and Turkey Pens

Cattle Ear Tag Uses: Chlorpyrifos impregnated ear tags (5 percent a.i.) are used on cattle. The volume and frequency of chlorpyrifos use for cattle ear tags is unavailable. Wildlife risks have not been assessed for the use of cattle ear tags. Leaching rates are unknown, consequently the estimation of terrestrial and aquatic EECs and risks have not been assessed.

Turkey Pen Spray Uses: Directions for chlorpyrifos use on outdoor turkey pens is a spray treatment. Soils in outdoor turkey pens may be sprayed twice at 4 lbs ai/A at a minimum 28-day, retreatment interval. Soil is sprayed before turkeys are transferred to the pens. Direct application to turkeys is prohibited. The following table shows risk quotients for turkey pen applications, assuming there is vegetation on the floor of the pens.

Risk Quotients for Treated Turkey Pens
(Foliar Spray; 4 lbs ai/A; 2 Applications; 28-Day Interval)
(Terrestrial EEC's Based on Fate Model; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	574 - 1020 ppm	102 ppm 147 ppm 647 ppm	5.6 - 10 3.9 - 6.9 0.89- 1.6
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	64 - 574 ppm	102 ppm 147 ppm 647 ppm	0.63 - 5.6 0.44 - 3.9 0.10 - 0.89
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	64 - 574 ppm	462 ppm 647 ppm 3233 ppm	0.14 - 1.2 0.10 - 0.89 0.020- 0.18
Mammalian Subacute Dietary LC_{50}	574 - 1020 ppm	1330 ppm	0.43 - 0.77
Mammalian Reproduction NOAEL	574 - 1020 ppm	10 ppm	57 - 100
Avian Subacute Dietary LC_{50}	574 - 1020 ppm	136 ppm	4.2 - 7.5
Avian Reproduction NOAEL	574 - 1020 ppm	25 ppm	23 - 41
Freshwater Fish Acute LC_{50}	28.9 ppb	1.8 ppb	16
Fish Reproduction NOAEC	14 - 25.2 ppb	0.57 ppb	25 - 44
Aquatic Invertebrate Acute LC_{50}	28.9 ppb	0.10 ppb	290
Freshwater Invert. Reproduction NOAEC	14 - 25.2 ppb	0.04 ppb	350 - 630
Estuarine Fish Acute LC_{50}	28.9 ppb	0.96 ppb	30
Estuarine Fish Reproduction NOAEC	14 - 25.2 ppb	0.28 ppb	50 - 90
Estuarine Invertebrate Acute LC_{50}	28.9 ppb	0.035 ppb	830
Estuarine Invert. Reproduction NOAEC	14 - 25.2 ppb	< 0.0046 ppb	>3000 > 5500
Estuarine Algae Acute EC_{50}	28.9 ppb	140 ppb	0.21

Risk Summary for Turkey Pen Uses: Risk quotients for chlorpyrifos sprayed twice in outdoor turkey pens exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.02-10), subacute (0.43-0.77), and reproduction NOAEL (57-100), avian subacute (4.2-7.5), and reproduction NOAEL (23-41), freshwater fish acute (16) and reproduction NOAEC (25-44), aquatic invertebrate acute (290) and reproduction NOAEC (350-630), estuarine fish acute (30) and reproduction NOAEC (50-90), estuarine invertebrate acute (830) and reproduction NOAEC (>3000->5500), and estuarine algae (0.21).

Piscivorous mammals are exposed to estimated residues in the fish viscera of 55 ppm and whole fish of 38 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but more than the avian reproductive NOAEL of 25 ppm.

(viii) Commercial and Residential Uses (Christmas Tree Farms, Ornamentals (Nursery/landscape), Homeowners (Fruit/Nut and Citrus Trees), Golf Courses (turf), Lawn Care, and Residential Perimeter Pest Control)

According to BEAD, non-agricultural, outdoor treatments with chlorpyrifos total about 3,425,000 lbs a.i., excluding termite uses. These sites can be treated by certified applicators (PCOs) and non-certified individuals, such as homeowners. Additional details are not given for the various uses, hence quantification of chlorpyrifos volumes are addressed below.

Christmas Tree Foliar Spray Uses: Directions for chlorpyrifos use on Christmas trees of various species in nurseries and plantations on registered labels include aerial sprays twice at 1 lb ai/A or applied as a cut stump drench at 3 lbs ai/100 gallons. Use on tree plantations is limited to Connecticut, Maine, Maryland, Michigan, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, Washington, and Wisconsin. The following table shows risk quotients for Christmas tree uses.

Risk Quotients for Christmas Tree Plantations
(Foliar Spray; 1 lb ai/A; 2 Applications; 7-Day Interval)
(Terrestrial EEC's Based on Fate Model; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams)	203 - 360 ppm	102 ppm	2.0 - 3.5
(35 grams)		147 ppm	1.4 - 2.4
(1000 grams)		647 ppm	0.31 - 0.56
Mammalian Insectivores LD_{50} (15 grams)	23 - 203 ppm	102 ppm	0.23 - 2.0
(35 grams)		147 ppm	0.16 - 1.4
(1000 grams)		647 ppm	0.036- 0.31
Mammalian Granivores LD_{50} (15 grams)	23 - 203 ppm	462 ppm	0.050- 0.44
(35 grams)		647 ppm	0.036- 0.31
(1000 grams)		3233 ppm	0.007- 0.063

Mammalian Subacute Dietary LC_{50}	203 - 360 ppm	1330 ppm	0.15 - 0.27
Mammalian Reproduction NOAEL	203 - 360 ppm	10 ppm	20 - 36
Avian Subacute Dietary LC_{50}	203 - 360 ppm	136 ppm	1.5 - 2.6
Avian Reproduction NOAEL	203 - 360 ppm	25 ppm	8.1 - 14
Freshwater Fish Acute LC_{50}	11 ppb	1.8 ppb	6.1
Fish Reproduction NOAEC	5.4- 10 ppb	0.57 ppb	9.5 - 18
Aquatic Invertebrate Acute LC_{50}	11 ppb	0.10 ppb	110
Freshwater Invert. Reproduction NOAEC	5.4- 10 ppb	0.04 ppb	135 - 250
Estuarine Fish Acute LC_{50}	11 ppb	0.96 ppb	11
Estuarine Fish Reproduction NOAEC	5.4- 10 ppb	0.28 ppb	19 - 36
Estuarine Invertebrate Acute LC_{50}	11 ppb	0.035 ppb	310
Estuarine Invert. Reproduction NOAEC	5.4- 10 ppb	< 0.0046 ppb	>1200 > 2200
Estuarine Algae Acute EC_{50}	11 ppb	140 ppb	0.079

Risk Summary for Maximum Christmas Tree Spray Uses: Chlorpyrifos aerially sprayed on Christmas trees in plantations yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.007-3.5), subacute (0.15-0.27) and reproduction NOAEL (20-36); avian dietary (1.5-2.6) and reproduction NOAEL (8.1-14), freshwater fish acute (6.1) and reproduction NOAEC (9.5-18), aquatic invertebrate acute (110) and reproduction NOAEC (135-250), estuarine fish acute (11) and reproduction NOAEC (19-36), estuarine invertebrate acute (310) and reproduction NOAEC (>1200->2200), and estuarine algae (0.079).

Piscivorous mammals are exposed to estimated residues in the fish viscera of 31 ppm and whole fish of 15 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but more than the avian reproductive NOAEL of 25 ppm.

Christmas Tree Stump Drench Uses: Directions for chlorpyrifos use on tree stumps on registered labels include chlorpyrifos applied as a cut stump drench at 3 lbs ai/100 gallons. Description of use rates such as "drench" and "apply to runoff" pose a problem for quantifying terrestrial and aquatic EECs for vegetation, insects, etc. According to these use instructions, the treatment concentration may be as high as 3,595 ppm (i.e., 3 lbs/gallon x 119,830 / 100 gal. = 3,595 ppm).

Wildlife exposures to chlorpyrifos-treated tree stumps may occur in several ways. Some bird species or small mammals may feed on drenched vegetation, seeds or invertebrates, or will drink the runoff from treated stumps or small puddles, or will bathe in the runoff. Birds may also ingest

a pesticide when they preen their feathers after bathing in a puddle or brushing against wet vegetation.

Acute risks to terrestrial wildlife can be estimated using a non-standard risk methodology by calculating how many milliliters of spray are equivalent to the LD50 values. A solution of 3,595 ppm is equivalent to 3.6 mg of chlorpyrifos per ml. Toxic levels (ml or drops per species) can be determined from the LD50 values and body weights of wildlife species. For example, a 0.0277 kg house sparrow with an acute LD50 value of 10 mg/kg has a median lethal dose of 0.277 mg, which yields a risk quotient of 13 for drinking one milliliter of the 3.6 ppm spray solution. Expressed in another way, 1 ml of the 3,595 ppm spray solution of chlorpyrifos contains the equivalent of 13 LD50 doses (RQs) for house sparrows. Given the pharmaceutical measure of about 20 drops per milliliter (verified by the weight measurement of one and ten drops from an eye dropper by laboratory personnel at the Patuxent Wildlife Laboratory, Maryland), 3.6 mg of chlorpyrifos in 1 ml equals 0.18 mg per drop of water. The following table estimates risk quotients for select avian and mammalian species drinking one drop of the spray solution.

Wildlife Risks from Tree Stump Drench Use Expressed as Number of Water Drops per LD_{50} and Risk Quotients per Drop
(1 ml of 3,595 ppm solution equals 0.18 mg/drop)

Species	LD_{50}	Body Wt. (kg)	mg/LD_{50}	Water Drops/LD_{50}[a]	Risk Quotient/Drop
House Sparrow	10	0.0277	0.277	1.5	0.65
Mammal (35 grams body wt.)	97	0.035	3.395	19	0.053[b]
Rat	97	0.200	19.4	110	0.009
Cockerel	34.8	1.500	52.20	290	0.003[c]
Mallard Duck	75.6	1.082	81.80	450	0.002[d]

[a] One tablespoon is equivalent to about 296 drops.
[b] A 0.025 kg mouse consumes 5 ml of water per day, which yields a RQ of about 5.3 based on drinking only from the spray runoff for one day.
[c] A 0.8 kg adult chicken consumes 200 ml of water per day, which yields a RQ of about 12 based on drinking only from the spray runoff for one day.
[d] A 2.5 kg adult domestic duck consumes about 500 ml of water per day, which yields an adjusted RQ of about 18 based on 300 ml of water consumed in one day.

Risk Summary for Christmas Tree Stump Drench Uses: Non-standard, risk quotients for wildlife drinking a single drop of the 3,595 ppm spray on drenched tree stumps exceeds levels of concern for several non-target terrestrial animals. Few species drink only one drop when they drink or are thirsty. A one-time consumption equivalent to one tablespoon (296 drops) is not unreasonable for most middle-sized wildlife species. Risk quotients for the least sensitive species at the bottom of the table are high (RQ = 12 for chickens and 18 for mallard ducks), if they consume the spray at normal water levels for one day. The LD_{50} value for a 1,000 gram mammal is the equivalent of drinking one (1) ounce of the 3,595 ppm spray solution (540 drops / 20 drops/ml / 28.35 grams/ounce = 0.95 ounces). For aquatic risk assessment, the quantification of EECs in adjacent aquatic habitats poses a complex problem. It is sufficient to say that the spray treatment of the stump may pose acute risks to aquatic organisms, if rainfall washed the spray

solution off the tree stumps into an adjacent aquatic areas.

Nursery Ornamental Uses: Nursery ornamentals may be sprayed broadcast or applied to foliage until the spray runs off with large tank sprayers or compressed air sprayers. Application rates with large tank sprayers are typically applied once or twice at 0.25-0.5 lbs ai/100 gallons. Aerial applications are not permitted in nurseries.

A non-standard, risk methodology for drinking exposures assessed above for tree stumps uses, can also be used to assess terrestrial wildlife risks for ornamental uses. The maximum registered use rate on ornamentals is 0.5 lbs ai/A or one-sixth the rate for tree stumps. Consequently the terrestrial risk quotients are one-sixth the values in the above table.

While the level of risks are reduced, the risk quotient for the house sparrow exceeds the level of concern for acute toxicity for endangered species for consumption of a single drop. Normal water consumption rates of a few to many drops, would increase the number of wildlife species that exceed levels of concern. Aquatic risks have not been assessed, based on these use rates.

Monitoring data from the San Diego Creek and the Upper Newport Bay watershed in southern California are reported by G. Fred Lee & Associates (Unpublished letter dated January 29,1999). The report shows frequent water samples with chlorpyrifos concentrations which exceed the toxicity levels for both *Ceriodaphnia* (80 ng/L) and *Mysidopsis* (35 ng/L). The example given for the San Diego Creek reported 430 ng/L chlorpyrifos and the presence of several other pesticides. The Upper Newport Bay watershed has substantial residential, vegetable agriculture and several commercial nurseries. The letter states “We are finding a variety of pesticides in our samples, some of which seem to be associated with their use at commercial nurseries.” Out of the 48 water samples collected between October 30, 1996 and August 25, 1998, 16 samples (33 %) exceed the toxicity level for *Ceriodaphnia* and 25 samples (52 %) exceed the toxicity value for *Mysidopsis*. On two occasions, chlorpyrifos concentrations were sufficiently high to produce toxic effects to fathead minnow larvae (Santa Ana Delhi Channel on March 1998 and Hines channel at Irvine Creek Drive in August 1998). The later sampling site is located just downstream from two large commercial nurseries.

Homeowner Ornamental Uses: Directions for homeowner use on ornamentals on registered labels permits chlorpyrifos to be sprayed with a 1.7% to 12% concentrate diluted with 15 to 30 gallons of water in hose-end sprayers. Ornamentals are sprayed to runoff. Description of use rates as "apply to runoff" is not quantifiable and poses a problem for calculating EECs. According to available label instructions, treatment concentrations may be 8,000 ppm (i.e., 120,000 ppm / 15 gallons = 8,000 ppm). Dow (1999 comments) indicated that the highest orchard use is 10,000 ppm for beetle control. The following table estimates the number of spray drops equal to the LD_{50} values and non-standard, risk quotients for select avian and mammalian species drinking one (1) drop of the 8,000 ppm spray solution.

Wildlife Risks from Ornamental Uses Expressed as Number of Water Drops per LD_{50} and Risk Quotients per Drop 12% Concentrate in 15 Gallons of water (1 ml of 8,000 ppm solution equals 0.4 mg/drop)					
Species	**LD_{50}**	**Body Wt. (kg)**	**mg/LD_{50}**	**Water Drops/LD_{50}[a]**	**Risk Quotient/Drop**
House Sparrow	10	0.0277	0.277	0.69	1.4
Mammal (35 grams body wt.)	97	0.035	3.395	8.5	0.12[b]
Rat	97	0.200	19.4	48.5	0.021
Cockerel	34.8	1.500	52.20	130	0.0077[c]
Mallard Duck	75.6	1.082	81.80	204	0.0049[d]

[a] One tablespoon is equivalent to about 296 drops.

[b] A 0.025 kg mouse consumes 5 ml of water per day, which yields a RQ of about 12 based on drinking only from the spray runoff for one day.

[c] A 0.8 kg adult chicken consumes 200 ml of water per day, which yields a RQ of about 30 based on drinking only the spray runoff for one day.

[d] A 2.5 kg adult domestic duck consumes about 500 ml of water per day, which yields an adjusted RQ of about 25 based on 300 ml of water consumed in one day.

Risk Summary for Maximum Homeowner Ornamental Uses: The 8,000 ppm aqueous spray exceeds the levels of concern for some terrestrial animals based on the consumption of only one drop. A one-time consumption equivalent to one tablespoon (296 drops) is not unreasonable for most middle-sized animal species. The footnotes for cockerels and mallard ducks suggest possible risks to these and other large species based on a single day's consumption of water. For aquatic risk assessment, the quantification of EECs in adjacent aquatic habitats poses a complex problem. It is sufficient to say that the spray treatment of ornamentals to runoff is likely to pose acute risks to aquatic organisms, if rainfall washes the spray solution off the ornamentals and the application runs off into an adjacent aquatic areas. The maximum use rate at 10,000 ppm would yield even higher risks to terrestrial and aquatic species, than the 8,000 ppm treatment. Dow states that the vast majority of ornamental uses are applied at 600 to 1200 ppm.

Aquatic exposures and risk quotients were not determined due to the lack of an appropriate models for this use. However, biomonitoring programs in California urban areas have identified homeowner uses on lawns, ornamentals and fruit trees as the toxic sources of chlorpyrifos in effluents from storm sewers, which is toxic to *Ceriodaphnia* in receiving waters [G. Fred Lee & Associates (Unpublished letter dated January 29,1999].

Homeowner Fruit Tree Uses: Directions for chlorpyrifos use on fruit trees on registered labels are as follows. Homeowner use on fruit, nut, and citrus trees are sprayed at 0.25-2 lbs ai/100 gallons (1-4 lbs ai/A). Residential orchards are likely to be considerably less than the 10-hectare area assumed in the GENEEC model and the presence of a 1-hectare pond on the edge of the orchard is unlikely. Runoff into streams and ditches is much more likely than into ponds. Since a model is not available for flowing waters, only terrestrial risks have been assessed for this use. The following table shows risk quotients for terrestrial species for use on residential fruit trees.

Risk Quotients for Homeowner Fruit, Nut and Citrus Trees (Ground Spray Treatment; 4 lbs ai/A; 1 Application) (Terrestrial EEC's Based on Nomograph)			
Species	**Exposure**	**Toxicity**	**Risk Quotient**
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	540 - 960 ppm	102 ppm 147 ppm 647 ppm	5.3 - 9.4 3.7 - 6.5 0.83- 1.5
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	60 - 540 ppm	102 ppm 147 ppm 647 ppm	0.59 - 5.3 0.41 - 3.7 0.093- 0.83
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	60 - 540 ppm	462 ppm 647 ppm 3233 ppm	0.13 - 1.2 0.093- 0.83 0.019- 0.17
Mammalian Subacute Dietary LC_{50}	540 - 960 ppm	1330 ppm	0.41 - 0.72
Mammalian Reproduction NOAEL	540 - 960 ppm	10 ppm	54 - 96
Avian Subacute Dietary LC_{50}	540 - 960 ppm	136 ppm	4.0 - 7.1
Avian Reproduction NOAEL	540 - 960 ppm	25 ppm	22 - 38

Risk Summary for Homeowner Fruit Tree Uses: Chlorpyrifos sprayed twice to soil on almond orchard floor at 4 lbs ai/A yields risk quotients which exceed the levels of concern for most terrestrial animals. Risk quotients are mammalian acute (0.019-9.4), subacute (0.41-0.72) and reproduction NOAEL (54-96), avian subacute (4.0-7.1) and reproduction NOAEL (22-38).

Aquatic exposures and risk quotients were not determined for this use due to the lack of an appropriate models for this use. However, biomonitoring programs in California urban areas have identified homeowner uses on lawns, ornamentals and fruit trees as the toxic sources of chlorpyrifos in effluents from storm sewers, which is toxic to *Ceriodaphnia* in receiving waters [G. Fred Lee & Associates (Unpublished letter dated January 29,1999].

Maximum Applications on Golf Course Turf: The volume of chlorpyrifos applied nationally on golf course turf and typical use rates have not been reported. Directions for chlorpyrifos use on golf course turf include spray and granular formulations. The application rate, number of applications and interval between applications are the same as those used in a field study on golf courses in Central Florida. The use in the Florida field study was supposed to represent the maximum seasonal use rates. Risk quotients estimated in the following two tables assume maximum application rates of chlorpyrifos on golf course turf. For spray applications, Dursban 50W Nursery is labeled for a 4 lbs ai/A application to control white grubs, but the label does not indicate a limit on the number of applications or provide a retreatment interval for control of white grubs. The only retreatment interval cited on the label for turf is 1 to 2 weeks for a 2 lbs ai/A use to control the adult form of one white grub species (i.e., black turfgrass ataenius adults). EFED assumed a 30-day retreatment interval for the spray use, since the label specifies no use limit and a Florida golf course field study cites 21 days as the minimum treatment interval. The same use rate and retreatment interval was assessed for granular treatment of golf courses based

on the use pattern Dow tested on the Florida golf course field study.

Risk Quotients for Maximum Golf Course Turf Use
(Ground Spray Treatment; 4 lbs ai/A; 2 Applications; 30-Day Interval)
(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	568 - 1,009 ppm	102 ppm 147 ppm 647 ppm	5.6 - 9.9 3.9 - 6.9 0.88 - 1.6
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	63 - 568 ppm	102 ppm 147 ppm 647 ppm	0.62 - 5.6 0.43 - 3.9 0.097 - 0.88
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	63 - 568 ppm	462 ppm 647 ppm 3233 ppm	0.14 - 1.2 0.097 - 0.88 0.019 - 0.18
Mammalian Subacute Dietary LC_{50}	568 - 1,009 ppm	1330 ppm	0.43 - 0.76
Mammalian Reproduction NOAEL	568 - 1,009 ppm	10 ppm	57 - 100
Avian Subacute Dietary LC_{50}	568 - 1,009 ppm	136 ppm	4.2 - 7.4
Avian Reproduction NOAEL	568 - 1,009 ppm	25 ppm	23 - 58
Freshwater Fish Acute LC_{50}	29 ppb	1.8 ppb	16
Fish Reproduction NOAEC	14.6 - 25.5 ppb	0.57 ppb	26 - 45
Aquatic Invertebrate Acute LC_{50}	29 ppb	0.10 ppb	290
Freshwater Invert. Reproduction NOAEC	14.6 - 25.5 ppb	0.04 ppb	370 - 640
Estuarine Fish Acute LC_{50}	29 ppb	0.96 ppb	30
Estuarine Fish Reproduction NOAEC	14.6 - 25.5 ppb	0.28 ppb	52 - 91
Estuarine Invertebrate Acute LC_{50}	29 ppb	0.035 ppb	830
Estuarine Invert. Reproduction NOAEC	15.6 - 25.5 ppb	< 0.0046 ppb	> 3200 > 5500
Estuarine Algae EC_{50}	29 ppb	140 ppb	0.21

Risk Summary for Maximum Golf Course Spray Treatments Uses: Chlorpyrifos sprayed twice at a one-month interval at 4 lbs ai/A yields risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.097-9.9), subacute (0.43-0.76) and reproductive NOAEL (57-100), avian subacute (4.2-7.4) and reproductive NOAEL (23-58), freshwater fish acute (16) and reproductive NOAEC (26-456), aquatic invertebrate acute (290) and reproductive NOAEC (370-640), estuarine fish acute (30) and reproductive NOAEC (52-91), estuarine invertebrate acute (830) and reproductive NOAEC (>3200->5500), and estuarine algae (0.21). The above aquatic risk quotients for golf course turf uses may be too high, because the GENEEC Model does not include reduced runoff due to ground cover. However, risks to aquatic species do exist as indicated by several fish kills that were found in water hazards and a pond adjacent to treated turf areas during a central Florida golf

course field study.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 57 ppm and whole fish of 40 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but more than avian reproductive NOAEL of 25 ppm.

Granular Risk Quotients for Golf Course Turf
(Soil Broadcast, Unincorporated; 4 lbs ai/A; 2 Applications, 30-Day Interval)
(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)

Species	Toxicity	Exposure	Toxicity Dose	Risk Quotient
Mammalian Acute LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	97 mg/kg	41.7 mg/ft^2*	1.5 mg 3.4 mg 97 mg	28 12 0.43
Avian Acute Oral LD_{50} (27.7 grams body wt.)	10 mg/kg	41.7 mg/ft^2*	0.28 mg	150
Freshwater Fish Acute LC_{50}	1.8 ppb	25.3 ppb		14
Fish Reproduction NOAEC	0.57 ppb	12.8 - 22 ppb		22 - 39
Aquatic Invertebrate Acute LC_{50}	0.10 ppb	25.3 ppb		250
Freshwater Invert. Reproduction NOAEC	0.04 ppb	12.8 - 22 ppb		320 - 550
Estuarine Fish Acute LC_{50}	0.96 ppb	25.3 ppb		26
Estuarine Fish Reproduction NOAEC	0.28 ppb	12.8 - 22 ppb		46 - 79
Estuarine Invertebrate Acute LC_{50}	0.035 ppb	25.3 ppb		720
Estuarine Invert. Reproduction NOAEC	< 0.0046 ppb	12.8 - 22 ppb		>2800 >4800
Estuarine Algae EC_{50}	140 ppb	25.3 ppb		0.18

* mg ai/foot^2 = $\frac{4.0 \text{ lb ai/A} \times 453{,}590 \text{ mg/lb}}{43{,}560 \text{ ft}^2}$ = 41.7 mg/ft^2

Risk Summary for Maximum Golf Course Granular Treatments Uses: Chlorpyrifos granules broadcast on golf course turf at 4 lbs ai/A twice at a one-month interval yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.43-28); avian acute (150); freshwater fish acute (14) and reproductive NOAEC (22-39), aquatic invertebrate acute (250) and reproductive NOAEC (320-550), estuarine fish acute (26) and reproductive NOAEC (46-79), estuarine invertebrate acute (720) and reproductive NOAEC (>2800->4800), and estuarine algae (0.18).
Piscivorous mammals are exposed to estimated residues in the fish viscera of 50 ppm and whole fish of 35 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but more than the avian reproductive NOAEL of 25 ppm. Again, the aquatic risk quotients may be a little too high, because the GENEEC Model

does not incorporate reductions in runoff due to ground cover. However, in a central Florida golf course field study, lethal chlorpyrifos residues were measure in water in two out of four treated areas on Day 0 (1.69 and 2.55 ppb on replicates G5 and G8, respectively). On several occasions during the field study, dead fish were found in water hazards and a pond adjacent to treated turf areas.

Comparison of Formulation Risks for Maximum Golf Course Uses: Comparison of risk quotients for spray and granular applications on golf course turf at the same use rates suggest that the granular formulation is more acutely toxic to birds, mammals and other terrestrial species, while the spray formulation is only slightly more toxic to aquatic species.

Golf Course Field Study in Central Florida: In a Central Florida golf course field study, chlorpyrifos was applied at 4 lbs ai/A per treatment on four replicates. The two chlorpyrifos formulations studied were Dursban Turf Insecticide (a liquid spray formulation) or with Dursban 2.5 Granular Insecticide. Four additional golf courses were used as controls. Two treatments were applied to each replicate golf course during the summer of 1992 at a minimum interval of 21 days between treatments. The golf courses ranged from 50 to 250 acres with treatment areas ranging from 4.7 to 7.2 acres.

Chlorpyrifos levels were measured in various environmental samples (i.e., soil and water samples). The soil sample was a core of grass, thatch and 10 cm of soil. Residues on treated grass alone were not measured. Residue measurements are summarized in the tables below for liquid and granular treatments.

CHLORPYRIFOS RESIDUES ON GOLF COURSES SPRAYED AT 4 LBS AI/A				
Substrate (1st & 2nd Appl.)	Initial Mean Conc.	Initial Mean Ranges	Highest Conc.	EFED Estimated Initial Conc. [a]
1st Soil (10 cm)	1.57 ppm	1.42-1.75 ppm	2.3 ppm	2.2 ppm
2nd Soil (10 cm)	2.21 ppm	1.50-3.50 ppm	3.5 ppm	2.48 ppm
1st Water (ppb)	< 1.0 ppb	not detected	< 1.0 ppb	14.75 ppb
2nd Water (ppb)	< 1.0 ppb	not detected	< 1.0 ppb	29.03 ppb

CHLORPYRIFOS RESIDUES ON GRANULAR-TREATED GOLF COURSES APPLIED AT 4 LBS AI/A				
Substrate (1st & 2nd Appl.)	Initial Mean Conc.	Initial Mean Ranges	Highest Conc.	EFED Estimated Initial Conc. [a]
1st Soil (10 cm)	2.83 ppm	1.10- 6.86 ppm	16.8 ppm	2.2 ppm

2nd Soil (10 cm)	4.41 ppm	1.60- 9.37 ppm	15.2 ppm	2.45 ppm
1st Water (ppb)	< 1.0 ppb	not detected	< 1.0 ppb	13.28 ppb
2nd Water (ppb)	0.905 ppb	n.d.-1.52 ppb	2.55 ppb	25.31 ppb

[a] Chlorpyrifos is assumed to be uniformally dispersed to a 4-inch depth to conform to the sampling depth.

Comparison of measured residues reported in the field study to EFED estimated exposures in the above tables shows that measured chlorpyrifos residue levels in soils are similar to levels estimated for the same depth of soil. Measured residues in water were consistently lower than predicted EECs in water, but in at least one pond chlorpyrifos exceeded LC_{50} values for some fish, tadpole and aquatic invertebrate species. The mean residue levels of chlorpyrifos in soil were measured in the top 10 cm of soil. EFED suggests that measuring chlorpyrifos residues in soil to a depth of 10 cm immediately after application underestimates exposures to wildlife. It is expected that immediately after application, chlorpyrifos would be found in about the upper 1 cm of soil, until rainfall and/or watering leaches the chlorpyrifos residues deeper. Thus it is concluded that the reported, initial residue levels in soil underestimate soil concentrations and exposures by about 10 fold. Normally, the Agency does not use soil residue levels in terrestrial risk assessments, unless information is available that indicates that the pesticide bioconcentrates in soil organisms. At least slight bioaccumulation of chlorpyrifos in soil organisms might be expected, but soil bioaccumulation data are unavailable and therefore, not estimated in this risk assessment. The usual terrestrial exposure assessments estimate the "highest or upper level" EECs on vegetation, insects, fruits and seeds. In this field study, residue levels on turf were not measured. Some wildlife species utilizing golf courses can be expected to feed on grasses, insects, earthworms, etc. Since the Agency assesses terrestrial risks for residues on grass, the turf/soil samples measured in this study are not comparable to EECs assessed in EFED risk assessments.

Comparison of predicted aquatic EECs and measured chlorpyrifos residues in the turf field study, indicates that measured levels are consistently less than EECs used in the risk assessment for golf courses. It is acknowledged that the GENEEC Model may overestimate aquatic EECs when ground cover is present on treated areas. Also, prediction of aquatic ECCs is highly problematic for reasons discussed in the above corn and citrus field studies. In the Tampa area, the annual rainfall is approximately 124.5 cm, sixty percent of which occurs between June and September in the form of localized afternoon thunderstorms. Rainfall during the study period from late summer to early fall was lower than the long-term average during the same period. The treatment areas were spread over three counties (5 in Pinellas County, 5 in Hillsborough County and 2 in Pasco County), which accounts for the differences in rainfall levels among the replicates.

Out of sixteen water samples from aquatic areas adjacent to treated turf, only two samples exceeded the level of detection of 1 ppb (i.e., 1.69 and 2.55 ppb). Both water samples with measurable levels of chlorpyrifos were found in aquatic areas adjacent to granular-treated areas. The level of detection for water (1 ppb) is greater than the acute aquatic invertebrate EC_{50} values (i.e., 0.1 and 0.035 ppb), therefore the risk to aquatic invertebrates can not be assessed for most

aquatic areas. Researchers reported finding dead fish on several occasions during the field study in water hazards and a pond adjacent to treated areas.

Wildlife Mortality and Sublethal Observations: Results from a central Florida, golf course field study confirmed risks to terrestrial wildlife and aquatic organisms. Carcasses searches were made prior to each application to remove all dead animals. Transacts totaled 2400 m on each replicate with 1800 m along the turf perimeter and 600 m in the adjacent habitat. Approximately two hours were spent searching each replicate per sampling day. Evaluation of carcass removal indicates that overall, 50 % of the carcasses were removed or hidden by scavengers by the second day and 99 percent were removed by Day 4. Removal rates were similar between treatment groups. Wildlife carcasses were placed on the golf courses for detectability trials. Recovery rates were 90 % on the fairway, 83 % in the rough, and 31 % in the adjacent habitat. Overall recovery rates were 77 %, 68 % and 69 % for liquid treatments, granular treatments and reference replicates, respectively.

Results from wildlife censuses, collection of casualties and chlorpyrifos analyses of carcasses are summarized in the table below. Casualty levels found on the reference replicates is inflated as a result of extra casualties found during the increased amount of time spent conducting additional activities on reference replicates.

Out of the 26 carcasses collected during the field study, only six carcasses were analyzed. Two of those six carcasses showed the presence of chlorpyrifos residues and two animals (i.e., a double-crested cormorant and a southern toad) showed cholinesterase behavior, but were negative for chlorpyrifos. A Florida soft-shell turtle contained 1.09 ppm and a ribbon snake carcass contained 15.11 ppm chlorpyrifos. Wildlife utilize areas adjacent to golf courses more than the turf. However, some wildlife species, such as ducks, geese, robins, mockingbirds, etc., feed on grassy areas eating vegetation, insects and/or soil organisms. Historically, a high number of bird kills have been reported on golf courses treated with fast-acting carbofuran and diazinon. Presumably, the higher reporting of wildlife kills on golf courses is largely due to the open areas and high human traffic.

It should be noted that during the chlorpyrifos, terrestrial field study on golf courses, some fish kills were observed in aquatic areas adjacent to the chlorpyrifos-treated golf courses. The authors made the following comments in their report. "On several occasions fish were found dead in water hazards during the study, some of which were found in the study area and some which were found outside of the study area on test golf courses. The sponsor was notified of the occurrence and provided with water, sediment and fish samples. Any fish collected were shipped to the Sponsor for evaluation along with fourteen water samples and twelve sediment samples collected from water hazards where the dead fish were found. Since the study deals with terrestrial hazard and was not structured to evaluate aquatic hazard, the responsibility for reporting these occurrences was left with the Sponsor and are not discussed in this reported." Information on chemical analyses of the samples of fish, sediments, and water have not been received by EPA for review.

Lawn Care Uses: Several lawn care products exist, including EC, granular, scattered bait, and fertilizer formulations. The EC formulation may be applied commercially from a large tank sprayer or from a hose-end sprayer (mostly homeowners). Large tank spray applications usually are sprayed once or twice with 1 to 4 gallons/1,000 ft^2 (1 lb ai/A) or at 0.125 to 8 lbs ai/A with a 6-week typical minimum retreatment interval. The 8 lbs ai/A use rate is for sod farms to control fire ants and is not for homeowner use (Dursban 50W, 3-03-99). Hose-end sprayer treatments (mostly homeowners) use a 1.7 to 12% concentrate diluted by 10-30 gallons/lawn (as high as 8,000 ppm in water on lawn) (1 lb ai/A typical rate). Dry formulations, such as baits and fertilizer (i.e., 0.5 and 1% granules) are broadcast or spread by drop spreader at 1-2 lbs ai/A (typical use is 1 lb ai/A with 1 or 2 applications with a minimum of 6 weeks retreatment interval). Depending on the area, runoff from treated lawns may be more likely to flow into streams than ponds. Since the GENEEC Model reflects aquatic contamination by runoff and soil erosion, it is not a suitable model for grassy areas. Furthermore, most treated lawns are unlikely to cover 10 hectares around a 1-hectare pond. Since the GENEEC Model would yield unrealistic EECs, aquatic EECs have not been estimated. The following 2 tables assess terrestrial risks for lawn care uses of chlorpyrifos.

Risk Quotients for Moderate Lawn Care Applications
(Foliar Spray; 1 lb ai/A; 2 Applications; 42-Day Interval)
(Terrestrial EEC's Based on Fate Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	137 - 244 ppm	102 ppm 147 ppm 647 ppm	1.3 - 2.4 0.93 - 6.9 0.21 - 0.38
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	15 - 137 ppm	102 ppm 147 ppm 647 ppm	0.15 - 1.3 0.10 - 0.93 0.023- 0.21
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	15 - 137 ppm	462 ppm 647 ppm 3233 ppm	0.032- 0.30 0.023- 0.21 0.005- 0.042
Mammalian Subacute Dietary LC_{50}	137 - 244 ppm	1330 ppm	0.10 - 0.18
Mammalian Reproduction NOAEL	137 - 244 ppm	10 ppm	14 - 24
Avian Subacute Dietary LC_{50}	137 - 244 ppm	136 ppm	1.0 - 1.8
Avian Reproduction NOAEL	137 - 244 ppm	25 ppm	5.5 - 9.8

Risk Quotients for Maximum Sod Farm Applications
(Foliar Spray; 8 lb ai/A; 2 Applications; 42-Day Interval)
(Terrestrial EEC's Based on Fate Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	1097 - 1950 ppm	102 ppm 147 ppm 647 ppm	11 - 19 7.5 - 13 1.7 - 3.0

Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	122 - 1097 ppm	102 ppm 147 ppm 647 ppm	1.2 - 11 0.83- 7.5 0.19- 1.7
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	122 - 1097 ppm	462 ppm 647 ppm 3233 ppm	0.26- 2.3 0.19- 1.7 0.04- 0.34
Mammalian Subacute Dietary LC_{50}	1097 - 1950 ppm	1330 ppm	0.82- 1.5
Mammalian Reproduction NOAEL	1097 - 1950 ppm	10 ppm	110 - 2000
Avian Subacute Dietary LC_{50}	1097 - 1950 ppm	136 ppm	8.1 - 14
Avian Reproduction NOAEL	1097 - 1950 ppm	25 ppm	44 - 78

Risk Summary for Moderate and Maximum Lawn Care and Sod Uses: Risk quotients for chlorpyrifos sprayed twice for lawn care at 1 lb ai/A exceed the levels of concern for most non-target terrestrial animals. Risk quotients are mammalian acute (0.071-2.4), subacute (0.10-0.18), and reproduction NOAEL (14-24), avian subacute (1.0-1.8), and reproduction NOAEL (5.5-9.8). Aquatic exposures and risk quotients were not determined.

Risk quotients for chlorpyrifos sprayed twice on sod at sod farms at 8 lbs ai/A exceed the levels of concern for most wildlife categories. Risk quotients are mammalian acute (0.04-19), subacute (0.82-1.5), and reproduction NOAEL (110-2000), and avian subacute (8.1-14), and reproduction NOAEL (44-78).

Aquatic exposures and risk quotients were not determined due to the lack of an appropriate models for this use. However, biomonitoring programs in California urban areas have identified homeowner uses on lawns, ornamentals and fruit trees as the toxic sources of chlorpyrifos in storm sewer effluents al levels which are toxic to *Ceriodaphnia* [G. Fred Lee & Associates (Unpublished letter dated January 29,1999].

Residential Perimeter Uses: Directions for chlorpyrifos use on residential perimeter pest control on registered labels include liquid sprays, dusts, granules, and a micro-encapsulated liquid suspension. The Dursban 1-12 label permits several spray applications around homes. Outside surfaces of buildings maybe sprayed with chlorpyrifos at 5,250 ppm to control a large number of common insects, mites, ticks and spiders and to control wood-infesting insects. A perimeter band treatment 6 to 10 feet wide around a structure may be sprayed at 325 ppm. Lawns and other outside uses, such as trails, picnic and camping sites can be sprayed at levels ranging from 3 to 12 fl. oz./1,000 sq. ft. (i.e., 3.8 to 22.7 ppb). Aquatic risks have not been assessed for this use, because the GENEEC Model does not allow for reduced erosion from grassy areas or the relatively small treated areas around structures compared to 10 hectares surrounding a 1-hectare pond.

Residential pest control applications are assessed for risks in the following table which estimates the number of spray drops equal to the LD_{50} values and the risk quotients for select avian and mammalian species drinking one (1) drop of the spray solution. It is evident that species listed in

the table below are capable of drinking more than a single drop off leaves and other vegetation.

Risks from Maximum Residential Pest Use Expressed as Number of Water Drops per LD_{50} and Risk Quotients per Drop (1 ml of 5,250 ppm solution equals 0.26 mg/drop)					
Species	**LD_{50}**	**Body Wt. (kg)**	**mg/LD_{50}**	**Water Drops/LD_{50}[a]**	**Risk Quotient/Drop**
House Sparrow	10	0.0277	0.277	1.1	0.94
Mammal (35 grams body wt.)	97	0.035	3.395	13	0.077[b]
Rat	97	0.200	19.4	75	0.013
Cockerel	34.8	1.500	52.20	200	0.0050[c]
Mallard Duck	75.6	1.082	81.80	310	0.0032[d]

[a] One tablespoon is equivalent to about 296 drops.

[b] A 0.025 kg mouse consumes 5 ml of water per day, which yields a RQ of about 18 based on drinking only from the spray runoff for one day.

[c] A 0.8 kg adult chicken consumes 200 ml of water per day, which yields a RQ of about 44 based on drinking only the spray runoff for one day.

[d] A 2.5 kg adult domestic duck consumes about 500 ml of water per day, which yields an adjusted RQ of about 44 based on 300 ml of water consumed in one day.

Risk Summary for Maximum Residential Outdoor Pest Uses: The 5,250 ppm ai aqueous spray applied as a residential perimeter treatment would likely exceed acute levels of concern for at least one terrestrial animal listed in the above table, based only on consumption of a relatively few number of drops to less than one tablespoon (i.e., 290 drops).

For aquatic risk assessment, the quantification of EECs in adjacent aquatic habitats poses a complex problem. It is sufficient to say that rainfall may the result in runoff of chlorpyrifos residues applied as a perimeter pest treatment into an adjacent aquatic areas. Aquatic exposures and risk quotients were not determined due to the lack of an appropriate models for this use. However, biomonitoring programs in California urban areas have identified structural treatments and perimeter treatments as the toxic sources of chlorpyrifos in effluents from storm sewers, which is toxic to *Ceriodaphnia* in receiving waters [G. Fred Lee & Associates (Unpublished letter dated January 29, 1999].

(ix) Termiticide Uses

Indoor and Foundation Termiticide Uses: Three chlorpyrifos formulations (i.e., 1.7 EC, 2 EC and 4 EC) are registered for termite control. According to BEAD, the total volume of chlorpyrifos used for termite treatments for all types of buildings is 2,600,000 lbs ai. Most termite pesticide control operators use 0.75-1 percent solution. Wood insects may be treated with a 0.5-1 percent solution. The typical house treatment involves drilling holes about every 8 inches into the foundation or in the floor about 3 inches from the wall followed by injection of chlorpyrifos. Outside the house, a trench is dug around the outside foundation, the chlorpyrifos solution is sprayed into the trench as drench, and then the soil is replaced. To prevent seepage along underground water lines or drain lines to wells or aquatic areas, the soil may be removed and the pesticide solution is mixed into the soil before returning the soil to the fault area. The above

described method, if carefully followed should pose little risk to wildlife and aquatic species. However, several fish kill incidents have been reported which are associated with indoor termiticide uses.

In a registration presentation by DowElanco, Dow indicated the number of reported "surface water" incidents that were associated with termiticide uses. In 1997, 7.2 "surface water" incidents were reported per 100,000 structures; in 1998 the number had decreased to 4.3 per 100,000. Dow indicated that about 580,000 houses were treated in each of these years which totals about 67 reported incidents for these two years. Dow indicated that about 75 percent of the "surface water" incidents were fish kills and the remainder of the incidents were based on observations of water quality, smell, etc.

Aquatic exposures and risk quotients were not determined due to the lack of an appropriate models for termiticide use. However, biomonitoring programs in California urban areas have identified structural termiticide uses as toxic sources of chlorpyrifos in storm sewer effluents at levels which are toxic to *Ceriodaphnia* [G. Fred Lee & Associates (Unpublished letter dated January 29, 1999].

(x) Mosquito Adulticide Uses

Mosquito Larvicide Uses: Several chlorpyrifos formulations were registered for mosquito larvicide uses with direct application to aquatic areas. Since no chlorpyrifos registrant is supporting the data requirements for the larvicide applications, the mosquito larvicide use has been cancelled from all chlorpyrifos labels. Consequently, there is no need for risks to aquatic

and terrestrial animals to be assessed.

Mosquito Adulticide Uses: Four chlorpyrifos formulations for mosquito adulticide uses are registered by Clarke Mosquito Control Products, Inc. Mosquitomist One U.L.V., a 13.6 % formulation with 1 lb ai/gallon, makes up about [redacted] for adult mosquito use in residential and recreational areas. Mosquitomist One U.L.V. is sprayed either as a thermal fog or as an ultra low volume (ULV) nonthermal aerosol (cold fog) to control adult mosquitoes in residential, recreational, and other non-cropland areas where these insects are a problem. Preferably, applications are made during the cool hours of the night or early morning. Repeat sprayings are made as necessary. For the thermal fog application, 9 gallons are mixed in 91 gallons of No. 2 fuel oil or other fuel, diesel or kerosene-type oil. The mixture is sprayed at a rate of 52.5 gallons per hour at an average vehicle speed of 5 miles per hour to cover a swath of up to 300 feet. For ULV nonthernal aerosol (cold fog) application, applications are sprayed with droplets ranging in size from 5 to 30 microns and a mass median diameter (MMD) of 10 to 15 microns. The rate of application is 0.005 to 0.01 pounds of chlorpyrifos per acre based on an effective swath width of 300 feet. Aerial ULV applications are made at an altitude of 300 feet and at a rate of 0.023 pounds ai/A for an affective swath of 500 feet. Aerial use in Florida requires there be a declared emergency and State approval.

Mosquitomist 1.5 U.L.V., a 19.36 % formulation with 1.5 lbs ai/gallon, makes up about [redacted] for mosquito uses. Mosquitomist 1.5 U.L.V. also is for mosquito control in residential and recreational areas with the same uses and application rates as Mosquitomist One U.L.V..

Mosquitomist Two U.L.V., a 24.6 % formulation with 2 lbs ai/gallon, is applied as a ULV spray or diluted with water and applied as a residual foliage spray with ground or aerial equipment only as a ULV nonthermal aerosol (cold fog) application. Ground ULV applications may be made at 0.01-0.024 lbs ai/A. Aerial ULV applications are made at 0.01-0.024 lbs ai/A and residual foliage spray may be applied at 0.024 in light to medium vegetative covered areas and at 0.05 lbs ai/A in medium to heavy vegetative covered areas.

ULV Mosquito Master 412 is a mixture of 12 % chlorpyrifos (90 lbs/gallon of highly refined mineral oil) and 4 % permethrin (30 lbs/gallon) for use by public health officials as well as trained personnel. The formulation is an all temperature, quick knockdown, combination to control adult mosquito populations in residential and recreational areas and also for use against black flies, biting and non-biting midges. It is applied as a ULV nonthermal aerosol (cold fog) application. For ground applications, the mixture may be applied at 0.005 to 0.021 lbs ai/A chlorpyrifos and 0.0017-0.007 lbs ai/A permethrin. Aerial applications may be applied at 3.0 fluid ounces per acre.

UVL and thermal-fog sprays produce a mist intended to remain airborne longer than do the larger droplets produced by standard spray applications. Therefore, EFED's standard assumption of 5 percent deposition from aerial spray applications may be too conservative

when estimating how much spray may be directly deposited in a water body. Field studies on ULV applications with various pesticides indicate spray drift to aquatic areas of between 5 to 20 percent (Fenthion RED). Hence the 15 percent spray drift, deposition level used to assess risks is conservative, but it is not worst case. The following table indicates the risk to non-target species from mosquito adulticide ULV use at the maximum use rate and moderately conservative 15% spray drift.

Risk Quotients for Mosquito Use (Mosquitomist One and 1.5 U.L.V. Formulations)
(ULV Aerial Spray; 0.023 lb ai/A; 1 Application)
(Terrestrial EEC's Based on Nomogram; Aquatic EEC's assume 15 % Spray Drift and Water 3 and 6 Feet Deep)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	3.1 - 5.5 ppm	102 ppm 147 ppm 647 ppm	0.03 - 0.054 0.02 - 0.037 0.005- 0.009
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	0.34 - 3.1 ppm	102 ppm 147 ppm 647 ppm	0.003- 0.03 0.002- 0.02 0.0005-0.005
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	0.34 - 3.1 ppm	462 ppm 647 ppm 3233 ppm	0.0007-0.007 0.0005-0.005 0.0001-0.0009
Mammalian Subacute Dietary LC_{50}	3.1 - 5.5 ppm	1330 ppm	0.002 -0.004
Mammalian Reproduction NOAEL	3.1 - 5.5 ppm	10 ppm	0.31 -0.55
Avian Subacute Dietary LC_{50}	3.1 - 5.5 ppm	136 ppm	0.023 -0.040
Avian Reproduction NOAEL	3.1 - 5.5 ppm	25 ppm	0.124 -0.22
Freshwater Fish Acute LC_{50}	0.21 - 0.42 ppb	1.8 ppb	0.12 -0.23
Fish Reproduction NOAEC	0.21 - 0.42 ppb	1.09 ppb	0.19 -0.39
Aquatic Invertebrate Acute LC_{50}	0.21 - 0.42 ppb	0.10 ppb	2.1 - 4.2
Freshwater Invert. Reproduction NOAEC	0.21 - 0.42 ppb	0.04 ppb	5.2 - 10
Estuarine Fish Acute LC_{50}	0.21 - 0.42 ppb	0.96 ppb	0.22- 0.43
Estuarine Fish Reproduction NOAEC	0.21 - 0.42 ppb	0.28 ppb	0.75- 1.5
Estuarine Invertebrate Acute LC_{50}	0.21 - 0.42 ppb	0.035 ppb	6.0 - 12
Estuarine Invert. Reproduction NOAEC	0.21 - 0.42 ppb	< 0.0046 ppb	46 - 91
Estuarine Algae EC_{50}	0.21 -0.42 ppb	140 ppb	0.001-0.003

Risk Summary for Mosquito Adulticide Uses: Fifteen percent spray drift from chlorpyrifos sprayed aerially as ULV at 0.023 lbs ai/A for adult mosquito control yields risk quotients which exceed the levels of concern for most non-target aquatic animals. Risk quotients do not exceed the levels of concern for non-target terrestrial animals. Risk quotients are mammalian acute (0.0001-0.054), subacute (0.002-0.004), and reproduction NOAEL (0.31-0.55), avian subacute (0.023-0.40) and reproduction NOAEL (0.12-0.22), freshwater fish acute (0.12-0.23) and reproduction NOAEC

(0.19-0.39), aquatic invertebrate acute (2.1-4.2) and reproduction NOAEC (5.2-10), estuarine fish acute (0.22-0.43) and reproduction NOAEC (0.75-1.5), estuarine invertebrate acute (6.0-12) and reproduction NOAEC (>46->91), and estuarine algae (0.0015-0.003).

Piscivorous mammals are exposed to estimated residues in the fish viscera of 1.64 ppm and whole fish of 0.56 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm and less than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Risk quotients for non-target aquatic animals in shallow water 0.5 feet deep would be 12 times higher than the reported value in each aquatic category. Shallow waters are important habitats for reproduction of amphibians. Toxicity data indicate that young toad tadpoles are slightly more sensitive to chlorpyrifos than the most sensitive freshwater fish species.

Risk Summary of All Outdoor Chlorpyrifos Uses: Application of chlorpyrifos poses acute and reproductive risks to many non-target aquatic and terrestrial animals for all outdoor uses reviewed. The risk quotients for all chlorpyrifos uses exceed the levels of concern for most terrestrial and aquatic categories. In general, risk quotients are greater among estuarine species, than freshwater species. Terrestrial animals are at less risk than aquatic species. Birds appear to be more at risk than most mammalian species. Aquatic risk quotients for ground spray applications are less than aerial spray applications at the same application rate. Reproductive risk quotients for granular applications are omitted because a standard method is not available, not for the lack of possible risks.

Results from field studies on Iowa corn, California citrus, and Florida golf courses indicate that chlorpyrifos applications adversely affect many types of wildlife. Wildlife casualties which were found on chlorpyrifos-treated sites and tested positive for chlorpyrifos residues include small mammals, birds, snakes, a turtle, adult toads, adult frogs, and tadpoles. Fish kills were found adjacent to both sprayed citrus groves and chlorpyrifos-treated golf courses. These fish kills were found even though none of the field studies included monitoring effects on aquatic animals. Both spray and granular treatments resulted in dead wildlife.

Measured chlorpyrifos residues in some water samples from all three field studies exceed LC_{50} and EC_{50} values for non-target aquatic animals. Measured chlorpyrifos levels in water samples were as high as 486 ppb in the citrus field study, 115 ppb in the corn field study, and 2.55 ppb in the golf course field study. These chlorpyrifos levels found in water adjacent to treated areas certainly exceed the acute and chronic toxicity values for fish (1.8 and 0.96 ppb, respectively) and aquatic invertebrates (0.1 and 0.035 ppb, respectively).

Wildlife incident reports indicate that chlorpyrifos uses around homes, especially treatments associated with termiticide treatments have killed robins and fish. Recent revisions of wildlife incident reports list about 166 incidents of which 92 occurrences have been summarized in the following table. The balance of the 166 incidents have not been reviewed and/or lack adequate details. Termiticide treatments were the most frequently reported type of wildlife incident. In many termiticide incidents, it

is unclear if exposures came from indoor, outdoor or perimeter treatments. If the source of exposure from a termite or home use was not reported, it was listed under the "Termiticide: Home" category.

NUMBER OF REPORTED CHLORPYRIFOS WILDLIFE INCIDENTS BY CATEGORY						
Pesticide Use (# of incidents)	Fish	Aquatic Invertebrates	Amphibians	Reptiles	Birds	Mammals
Termiticide: Homes (41)	31	2	1	1	8	4
Rodding (5)	5	3	2			
Perimeter (1)	1				1	
Yard (6)	4				2	
Field crop (3)	3		1			
Citrus (1)	1	1	1			
Peanuts (3)	3					
Soybeans (1)	1				1	
Wheat (1)	1					
Corn (1)	1					
Golf Course (6)	4				2	
Standing Water (1)	1	1	1	1	1	
Unk. Use (9)	5				4	
Misuse (2)	1			1		
Disposal (3)	3					
Spill (7)	7	1	1	1	1	
Total (92)	72	8	7	4	20	4

Recent bioassay monitoring in the San Francisco Bay area has detected diazinon and chlorpyrifos in discharges from both sewage treatment plants (POTWs) and municipal storm drain systems. Aquatic toxicity of these two organophosphate pesticides appear to be additive. In addition, some toxicity identification evaluations conducted by dischargers, state agencies, and USEPA Environmental Research Laboratory in Duluth, have identified one or both of these pesticides as toxicants in urban discharges in Arizona, Kentucky, Nevada, and Texas (Kolb, 1996).

Bioassay of rainfall samples in Sacramento and San Francisco area show chlorpyrifos residue levels which are toxic to *Ceriodaphnia dubia*, the invertebrate component of EPA's three species bioassay test (Connor, 1996). Measured chlorpyrifos levels in urban runoff exceed lethal levels to aquatic invertebrates in the Calabazas Creek in the Santa Clara Valley (up to 103 ng/L) and tributaries of the Castro Valley Creek (up to 378 ng/L) (Katznelson and Mumley, 1997)

Invertebrate bioassays of aquatic habitats areas adjacent to agricultural areas in the San Joaquin Basin also show chlorpyrifos toxicity. During a year and a half, bioassay study, a 43-mile reach of the San Joaquin River between the confluence of the Merced and Stanislaus Rivers has tested toxic to *Ceriodaphnia dubia* about 50 percent of the time (Foe, 1995). The investigators conclude that the toxicity appears to be caused by pesticides in storm and tailwater runoff from row and orchard crops. Chlorpyrifos was identified more often than any other pesticide as the source of toxicity. The authors determined that there are two seasonal, peak toxicity periods: January-March and April-June. The seasonal peak between January and March occurs during the rainy season and follows dormant spray applications on stone fruits, apple, pear and almond orchards between December and February. The seasonal chlorpyrifos peak between April and June results from irrigation of alfalfa and sugar beets treated in March to April. Irrigation begins in April. The water flows across the fields in furrows to creeks or collection canals which empty into the river. Irrigation water is flushed from the field in order to prevent toxic salt build-up in the soils. The tailwater is believed to be the primary vehicle responsible for transporting pesticides into surface water.

Reports from recent monitoring studies indicate that chlorpyrifos is also present at lethal levels to *Ceriodaphnia* in the Upper Newport Bay watershed in San Diego (G. Fred Lee and Associates, 1999). "We are finding a variety of pesticides in our samples, some of which seem to be associated with their use at commercial nurseries. As an example, the November 8, 1998 sample of San Diego Creek water in various parts of the Upper Newport Bay watershed showed 670 ng/L of diazinon and 430 ng/L of chlorpyrifos. It also contained several other detected pesticides ..." The chlorpyrifos LC_{50} values for *Ceriodaphnia* and *Mysidopsis*, opossum shrimp are 80 and 35 ng/L, respectively, which yield risk quotients of 5 and 12, respectively. The risks are made even higher by the additive toxicity of chlorpyrifos and diazinon for aquatic species. These monitoring levels portend serious impacts on invertebrate populations in these freshwater/estuarine areas.

Widespread contamination of toxic concentrations of chlorpyrifos are cited above in California and reported chlorpyrifos in urban discharges in Arizona, Kentucky, Nevada and Texas. This distribution of chlorpyrifos suggests that the pesticide toxicity problems are widespread, which are also consistent with the widespread low levels of chlorpyrifos in fish discussed earlier. With the exception of termiticide fish kills and some lethal fathead minnow larvae tests, most measurements of chlorpyrifos levels in water are such that they generally would appear only to effect aquatic invertebrate populations. However, based on chlorpyrifos levels measured in water in the three field studies (486 ppb in citrus, 115 ppb in corn, and 2.55 ppb in the golf course field study), the aquatic exposures for these uses certainly exceed lethal levels for many fish species too.

Application modifications for risk mitigation should consider the following changes. Maximum

application rates should be reduced to typical application rates. Spray applications should be limited to ground applications when possible (i.e., eliminate aerial uses where possible). The buffer zones should be enforced for spray drift. Insure that air blast applications are directed away from sensitive areas.

Terrestrial risk quotients are primarily affected by the rates of the individual applications (i.e., risks are reduced, if the total amount applied is spread out over several applications). For multiple applications, terrestrial risk quotients can also be reduced by increasing the minimum time interval between applications, preferably three or even two weeks between treatments. Aquatic risk quotients are most sensitive to the total amount applied per season (i.e., decreasing the application rate or reducing the number of applications can reduce aquatic risks more than increasing the minimum time interval between applications).

c. Endangered Species Concerns

Endangered species LOCs are exceeded for small mammals, birds, freshwater fish and invertebrates, and estuarine fish and invertebrates for most chlorpyrifos uses. Chlorpyrifos is used widely throughout the country with a large number of crop and non-crop uses with residues found in 26 percent of fish sampled from 314 monitoring sites. Hence, there is high potential for many endangered and threatened species to be exposed to chlorpyrifos. In two 1981 biological opinions, the Fish and Wildlife Service reviewed the use of 3 formulations (4 EC, 15 G, and 50 W on 12 crops, including tobacco, apples, cole crops, sorghum, peanuts, and corn; and Dursban 10 CR used as a mosquito larvicide. Jeopardy opinions were rendered for a few bird and amphibian species, a snake, and many species of fish and mussels. A third opinion in 1982 for Lorsban 4 EC and 15 G on soybeans, alfalfa, citrus and sunflowers found jeopardy for a few birds, many fish, an amphibian, and several mussels. In all, 105 use limitation determinations were specified for chlorpyrifos uses. Chlorpyrifos is included in a 1993 draft opinion on many chemicals for a number of crops. Conclusions in the draft suggest that some species may be in jeopardy. Jeopardy opinions were made for a few birds, many fish, a few amphibians, and many freshwater mussels. At present, several voluntary use limitations have been made.

The Agency has developed a program (the Endangered Species Protection Program) to identify pesticides whose use may cause adverse impacts on endangered and threatened species, and to implement mitigation measures that will address the adverse impacts. At present, the program is being implemented on an interim basis as described in a Federal Register notice (54 FR 27984-28008, July 3, 1989), and is providing information to pesticide users to help them protect these species on a voluntary basis. As currently planned, the final program will call for label modifications referring to required limitations on pesticide uses, typically as depicted in county-specific bulletins or by other site-specific mechanisms as specified by state partners. A final program, which may be altered from the interim program, will be described in a future Federal Register notice. The Agency is not imposing label modifications at this time. Rathr, any requirements for product use modifications will occur in the future under the Endangered Species Protection Program.

d. Uncertainties in the Risk Assessment

Several areas of uncertainty have been identified in the above summary sections. Significant areas of uncertainty include:

1) For some uses, the extent of cumulative risks from multiple applications methods and use rates was assessed independently, when applications methods or time between applications differ. In those cases, the GENEEC Model can not integrate the different application methods or variable timings. Hence, combined risks for maximum label use were not assessed. In order to estimate the maximum risks permitted by label uses, exposures for all applications should be jointly assessed for terrestrial and aquatic habitats.

2) Weight loss and reduced food consumption observed in avian dietary tests suggest that chlorpyrifos could be distasteful or repellant to birds or that the reduced food consumption is the result of sublethal effects which causes the sick birds to become lethargic and reduce all activities including feeding. Avian deaths in the corn, citrus, and golf course field studies and wildlife incidents indicate that, if repellency exists, it is not sufficient to prevent the death of birds, small mammals, and snakes.

3) Uncertainty exists on the number of toxicologically sensitive, wildlife species that are to be found in treated areas and the extent to which those wildlife species may consume lethal amounts of chlorpyrifos-treated granules. Results from the field studies are unclear, because relatively few carcasses were sufficiently intact to be analyzed for chlorpyrifos. For example, 3 out of 17 carcasses collected in the granular corn study were analyzed and only a short-tailed shrew tested positive for chlorpyrifos (2.1 ppm). In the golf course study, 4 out of 11 carcasses collected the granular treated area were analyzed for chlorpyrifos. Only one carcass, a Florida soft-shell turtle, tested positive for chlorpyrifos (1.09 ppm).

4) It is uncertain what adverse effects may occur to wildlife from dermal adsorption, preening and inhalation. Driver *et al*. 1991 found in laboratory tests with the organophosphate, methyl parathion that the routes of uptake was as follows: dermal greater that preening, greater or equal to oral and greater than inhalation. This pattern of importance in routes of exposure may not be consistent with other organophosphate pesticides, but the fact is that the Agency only has data and methods that can quantify risks from oral exposures. Furthermore, the toxic effects are likely to be additive for these various routes of exposure. Wildlife walk or crawl on the ground through treated areas where they are dermally exposed and the highest vapor concentrations would be found close to the ground for inhalation. Some wildlife species take dust baths to rid themselves of mites and other parasites and then preen their fur or feathers with their mouth.

5) From observations made during the field studies, it is apparent that some animals show signs of cholinesterase inhibition (birds and mammals). It is uncertain to what degree cholinesterase inhibition may cause death or modify an animals' behavior and its ability to avoid predators. High predation is suggested by the numerous feather spots and partial carcasses that were found during carcass searches in the corn study. High chlorpyrifos impacts on terrestrial wildlife are suggested by the seven carcasses which were analyzed for chlorpyrifos (three positive) and the three cases of cholinesterase inhibition

observed in the corn field study; 60 percent of the effected animals were confirmed as exposed to chlorpyrifos.

6) Reproductive risks to freshwater fish may be as much as 2 orders of magnitude higher than that calculated using the fathead minnow reproductive value used in this assessment. In the range of acceptable fish acute toxicity values, the fathead minnow acute LC_{50} value is the least sensitive fish species out of six freshwater fish species. The fathead minnow acute LC_{50} value is 203 ppb versus an acute LC_{50} of 1.8 ppb for bluegill sunfish, the most acutely sensitive freshwater fish species. Using an acute-to-chronic ratio for these two species, the NOAEC for bluegill sunfish is estimated to be 0.005 ppb (i.e., fathead minnow: LC_{50} 203 ppb / NOAEC 0.57 ppb = bluegill: LC_{50} 1.8 ppb / NOAEC; X = 0.005 ppb).

7) EECs used for estuarine species were the same as for a farm pond. While both areas act as a sink for chemical residues, the tidal flushing in estuarine areas may reduce water concentrations by dilution. On the other hand, the upper reaches of most estuarine areas are shallow water and if the tide is out when the runoff reaches the water, estuarine organisms will be exposed to higher concentrations than for those in a farm pond.

8) Risks to benthic organisms could not be assessed due to the lack of estimated chlorpyrifos residue levels in sediments. Chlorpyrifos is expected to mainly partition to sediments.

9) Biomonitoring data in California have shown toxic levels of chlorpyrifos in POTW effluents, rainfall, and 43-miles of the San Joaquin River in agricultural areas. Other states have also identified problems with toxic levels of chlorpyrifos in POTW effluents. The geographic extent of these problems are unknown. The extent of adverse effects can not be assessed, because the levels of chlorpyrifos were not analytically measured.

10) Results from a national fish residue study show chlorpyrifos in 20 percent of the fish sampled, it is uncertain whether the exposures are sufficient to adversely affect aquatic organisms. The widespread occurrence of chlorpyrifos in fish tissues and the extent of lethal chlorpyrifos levels in California suggest that chlorpyrifos may be a nationwide concern for aquatic organisms.

11) Aquatic risks have not been assessed for a myriad of aquatic habitats, such as marshes, streams, creeks, and shallow rivers, intermittent aquatic areas, etc., which are more extensive and are frequently more productive than 2-meter deep ponds. Risks to aquatic species in these shallow aquatic habitats are likely to be considerably greater than for organisms in a 2-meter deep pond (i.e., 6 to 13 fold higher risk quotients). Shallow water areas provide habitat for a diversity of aquatic organisms which are distinct from species found in deeper ponds or are only found in the shallow margins. For example, amphibians such as tadpoles and newts may spawn and develop in temporary, shallow pools of water. Bluegill sunfish typically spawn and fry inhabit the edge of ponds in water depths of 1 to 3 feet.

12) The extent to which chlorpyrifos and other pesticides might be responsible for the worldwide decline in populations of amphibians is not known. Toxicologists generally consider fish to be more

sensitive to pesticides than amphibians, but this is not the case with chlorpyrifos. The reported LC_{50} for tadpoles is about 1 ppb versus 1.8 ppb for the most sensitive fish species, bluegill, hence the risk quotients for fish would be considerably greater, about 20 fold, for tadpoles in 6-inch aquatic habitats (i.e., 12 (6-inch veersus 2-meter water depths) X bluegill LC_{50} 1.8 ppb / tadpole LC_{50} 1 ppb). Reported deaths of adult frogs and toads in the chlorpyrifos field studies and wildlife incidents suggest that these species may be sensitive to dermal exposures. Amphibians have skin which must be kept moist that may be more sensitive to dermal exposures than insects, fish, turtles, snakes, birds, and mammals. Chlorpyrifos exposures would appear to pose a potential risk to amphibians in both the terrestrial and aquatic habitats.

13) Chlorpyrifos-related deaths of snakes observed in the field studies indicates secondary toxicity to predators, which would increase the number of wildlife species of concern to carnivorous mammals, birds, turtles, and snakes. The extent of risk to carnivorous species is dependent on their sensitivity and the amount of chlorpyrifos present in the chlorpyrifos-poisoned animal.

14) The extent of additive toxicity to aquatic species of chlorpyrifos with diazinon and other organophosphate insecticides (Bailey *et al*., 1997 and Huang, Fujimura and Finlayson, 1994). Chlorpyrifos has also been found to be synergistic with atrazine, a widely used herbicide applied preplant to corn about the same time as the predominant chlorpyrifos use on corn (Pape-Lindstrom and Lydy, 1997). The presence of other pesticides and their combined toxicity with chlorpyrifos is a quantitative problem based on the proximity of other treated crops and the timing of their use with respect to chlorpyrifos applications. Certainly the proximity of pre-plant uses of atrazine and chlorpyrifos uses on corn are frequent events. Re-testing without DMSO and with much lower atrazine concentrations has been completed and shows synergism with OPs, but the new data are not yet available (i.e., has not yet been published).

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